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AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

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TITLE

AN ANALYSIS OF SOME ANNUAL RADIAL INCREMENT VARIATIONS IN ENGELMANN SPRUCE BEETLE-KILLED TREES

Forest Insect Laboratory
Coeur d'Alene, Idaho

SUBJECT—

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AGRICULTURAL RESEARCH ADMINISTRATION
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Division of Forest Insect Investigations

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Forest Insect Laboratory
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AN ANALYSIS OF SOME ANNUAL RADIAL INCREMENT VARIATIONS IN ENGELMANN SPRUCE BEETLE-KILLED TREES[1/]

INTRODUCTION

During the week of January 19, 1952 increment cores were extracted from a number of green Engelmann spruce trees and from trees killed since 1949 by the Engelmann spruce beetle (Dendroctonus engelmanni Hopk.) in the Fishhook Creek drainage near Avery, Shoshone County, Idaho. The cores were obtained primarily to investigate the possibility of using radial increment consistencies to establish the year of death of trees pre-currently killed by the beetle. Subsequent examinations of the core measurements, however, revealed some interesting facts about the growth characteristics of green and beetle-killed trees and an apparent association between the growth rate of some spruce trees and their incidence of beetle attack. Even though the results are very preliminary because of the limited sampling, they may be indicative of certain relationships between the spruce beetle and its favored host which may be further developed by additional studies.

The trees from which cores were extracted were located in Sections 28, 33, and 34; Township 44 North, Range 5 East, Boise Meridian. The stand in this vicinity was predominantly mature, of medium density, approximately 60 per cent Engelmann spruce (other species Alpine fir, western larch, lodgepole pine, white pine, and Douglas-fir), and on southern and western exposures. The spruce trees studied ranged from 19 to 48 inches d.b.h. and averaged about 5.5 (16-foot) logs in height. All were located within an elevational range of from 5,000 to 5,100 feet. An epidemic of the Engelmann spruce beetle occurred in the general area in 1952, and approximately 12.2 per cent of the spruce trees were killed in this year. Numerous spruce snags marked with old spruce beetle galleries were scattered throughout the stand as evidence that an endemic infestation existed prior to the present epidemic beetle outbreak.

METHODS

Increment cores were obtained from the north side of 13 green trees and 35 trees which the beetle had killed supposedly during the inclusive period 1949-52. The date of mortality of the latter trees was determined on the basis of external characters such as foliage color, foliage retention, small branch and twig retention, tightness of bark, freshness of cambium layer, presence of so-called secondary insects under the bark, and sapwood checking. The dating was strictly arbitrary, since no criteria have yet been developed for this purpose. In this manner 14 trees were marked as having been killed in 1952, 15 trees in 1951, 3 trees in 1950, and 3 trees in 1949.

1/ Prepared by Philip C. Johnson, Entomologist

The cores were measured in the laboratory the following week[1/], after first soaking them in water for a short time to overcome any discrepancies from the possible radial shrinkage in those from the older, and therefore drier, beetle-killed trees. Only the outer 25 rings, those most recently formed, were measured to the nearest 1/100 millimeter.

RESULTS

Annual Radial Increment Variations

The plotted annual radial increment (Figure 1) of the cored green trees shows distinct cyclic variation between 1925 and 1952. The increment pattern is characterized by two periods each of better-than-average and below-average growth. On the assumption that the rather marked increment variation in this fairly open grown, mature, uneven-aged spruce stand could be associated with periodic environmental changes, chiefly precipitation, this factor also has been plotted in Figure 1. The year-to-year comparison of increment and precipitation shows no particular relationship. Extended periods of below-average increment, however, appear to parallel more or less equal periods of deficient precipitation. Similarly, periods of prolonged above-average increment seemingly are related to concurrent periods of excessive precipitation. Although the increment rate has declined since reaching a maximum in 1950, the annual radial increment at the end of the 1952 growing season was above the mean for the 1925-52 period.

The average annual radial increment for trees killed by the Engelmann spruce beetle each year during the inclusive period 1949-52 is shown in Figure 2. Except for the trees killed in 1952, the beetle-killed trees show year-to-year radial increment variations that do not correlate with those of the green trees or of the precipitation pattern. Furthermore, the variations are noticeably more feeble throughout the entire 1925-52 period in contrast to those of the green trees. The annual increment variations of the 1952-killed trees display a high degree of similarity to those of the green trees.

Mean Annual Radial Increment

The 25-year pre-mortality mean annual radial increment averaged 0.35 millimeters for trees killed by the spruce beetle in 1949, 1950, and 1951 when endemic infestation conditions prevailed (Table 1). The mean for trees killed in 1952 during the current beetle epidemic was 0.84 millimeters, nearly 2½ times as great. The mean increment for green trees since 1925 was 1.01 millimeters.

1/ The help of Robert E. Denton, Entomologist, in measuring the cores is gratefully acknowledged; also that of Archie L. Gibson, Entomologist, who assisted in the mortality dating; and that of the Potlatch Forest Industries, Inc., of Lewiston, Idaho, for the field assistance of some of its forestry personnel -- Royce G. Cox, Robert Zellner, Edward Fleener, and Timothy Wade.

Table 1. 25-year mean annual radial increment of green and beetle-killed Engelmann spruce trees. Fishhook Creek, Shoshone County, Idaho

Year Killed	Period Studied	Mean Annual Increment (mm.)	Infestation Status
1949	1921-1949	0.33	Endemic
1950	1922-1950	0.28	Endemic
1951	1922-1951	0.37	Endemic
1952	1924-1952	0.84	Epidemic
Green	1925-1952	1.01	

Long-Term Increment Trend

In addition to their relatively low mean annual radial increment, the trees killed by the spruce beetle in 1949, 1950, and 1951 also exhibited a steadily declining radial increment trend (Figure 3). Except for the momentary annual increment increases in 1945 and 1949, shown in Figure 2, the trends are based upon an almost unbroken slowing up of growth in these beetle-killed trees. This phenomenon is commonly indicative of decreasing tree vigor.

The trends of the 1949-51 beetle-killed trees are in marked contrast to the generally rising increment trend of the green trees since 1925. In between is the trend of the 1952-killed trees which remained almost static during the period.

The percentage change in increment rate between the beginning and the end of the trend period is as follows:

Trees killed in	1949	-77 per cent
" "	1950	-56 " "
" "	1951	-70 " "
" "	1952	+12 " "
Green trees		+43 " "

Mortality Dating Beetle-Killed Trees

The year of death of the beetle-killed trees used in the study was determined by the external tree characteristics listed under "Methods". The plotted annual radial increment variations shown in Figure 1 were adjusted laterally until the last, or most recent, tree ring measurement coincided with these determined dates of death. An examination of the plotted variations did not disclose consistent increment abnormalities which could definitely be associated with any particular year, and which would have substantiated or rejected the determined tree mortality dates. The reason for this was primarily the low increment magnitude, the feeble variations of the 1949-51 beetle-killed trees, and sampling inconsistencies.

Such green tree increment "landmarks" as the "lows" of 1927 and 1940 and the "highs" of 1925, 1934, 1947, and 1950, for instance, were not apparent in the increment patterns of the beetle-killed trees.

In seeking an explanation for the consistently slower rate and declining trend of the radial increment of the trees beetle-killed in 1949, 1950, and 1951, two possibilities are suggested. Either these trees were larger than stand average and hence older, as indicated by their slower growth, or they were equal in size to the stand average and less vigorous, as again indicated by their slower growth. The average d.b.h. of the trees killed in 1949, 1950, 1951, and 1952 was 25, 25, 27, and 28 inches respectively. The average d.b.h. of the green trees in the stand was estimated to be 28 inches. Inasmuch as the sampled spruce stand was predominantly overmature, the uniformity in diameter classes of the beetle-killed and green trees indicates that the former, particularly those killed in 1949-51, were not the larger, older, slower-growing trees in the stand, but the more decadent, less vigorous ones.

CONCLUSIONS

The following conclusions might be based upon the results presented herein:

1. The green tree growth pattern of the high elevation Engelmann spruce stand sampled was more or less responsive to extended periods of precipitation abnormalities.

2. The green tree growth pattern over long periods exhibited definite cyclic tendencies.

3. During the endemic infestation of 1949, 1950, and 1951, the Engelmann spruce beetle attacked the slowest-growing trees in the stand.

4. The trees attacked during this endemic infestation period had steadily declined in rate of growth for the past 25-30 years.

5. Trees attacked during the epidemic infestation of 1952 were vigorous growing, both at the time of attack and for the preceding 25 years, but, even here, the trees attacked were those whose growth rate averaged below that of the green trees since 1940.

6. Based upon this evidence, there is reason to believe that the Engelmann spruce beetle may show some host tree selection -- that during endemic infestations it may limit its attacks to the slower-growing poor vigor trees in the stand and that during epidemic infestations its attacks are not so restrictive.

7. Radial increment patterns appear to be of little value in attempting to determine the year of death in beetle-killed trees that have been dead for more than one year.

FIG. 1

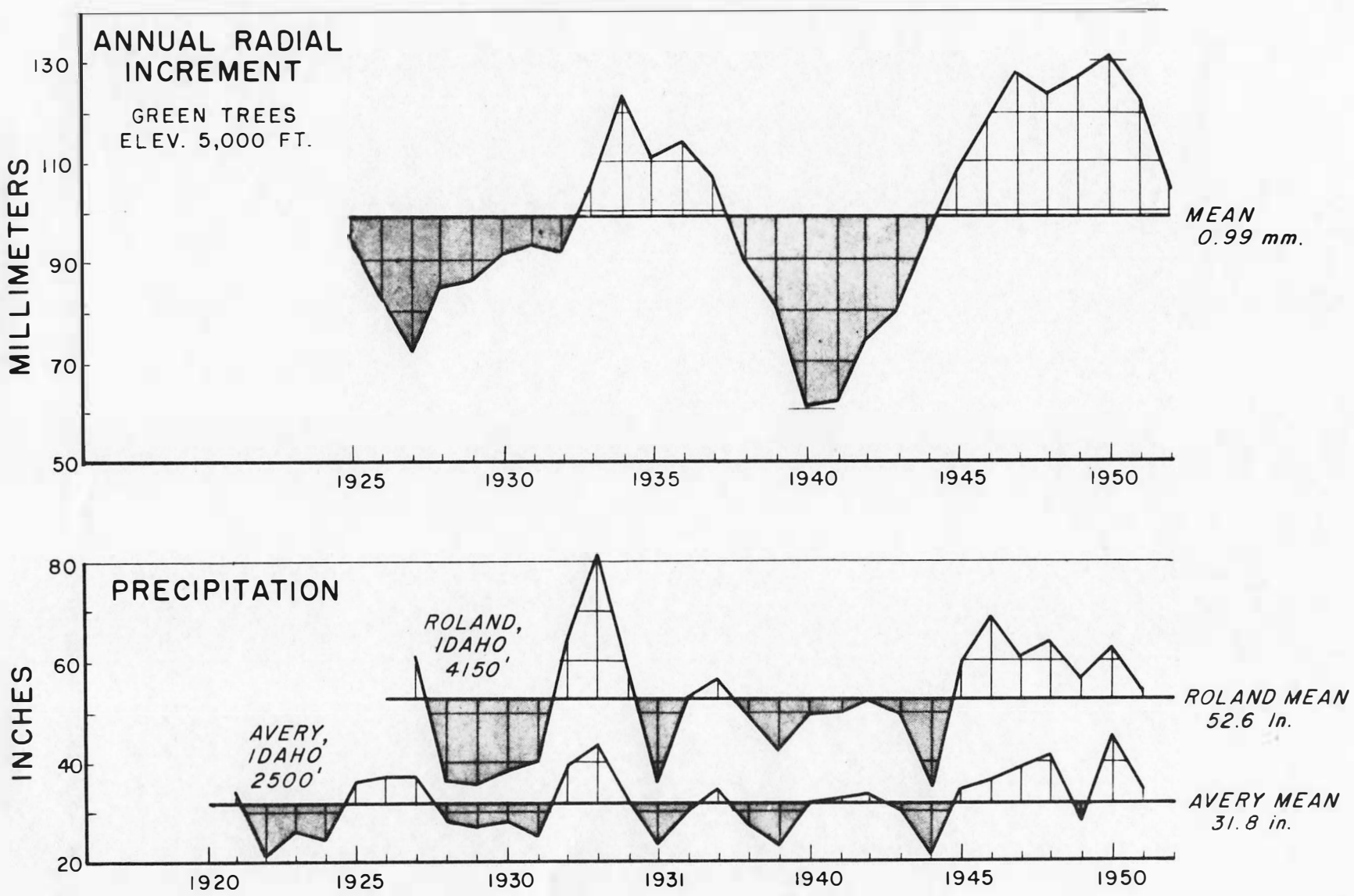
ANNUAL RADIAL INCREMENT
GREEN TREES
ELEV. 5,000 FT.
MILLIMETERS
130
110
90
70
50
1925
1930
1935
1940
1945
1950
MEAN
0.99 mm.
PRECIPITATION
INCHES
80
60
40
20
ROLAND, IDAHO 4150'
AVERY, IDAHO 2500'
1920
1925
1930
1931
1940
1945
1950
ROLAND MEAN
52.6 In.
AVERY MEAN
31.8 in.

FIG. 2

ANNUAL RADIAL INCREMENT VARIATION

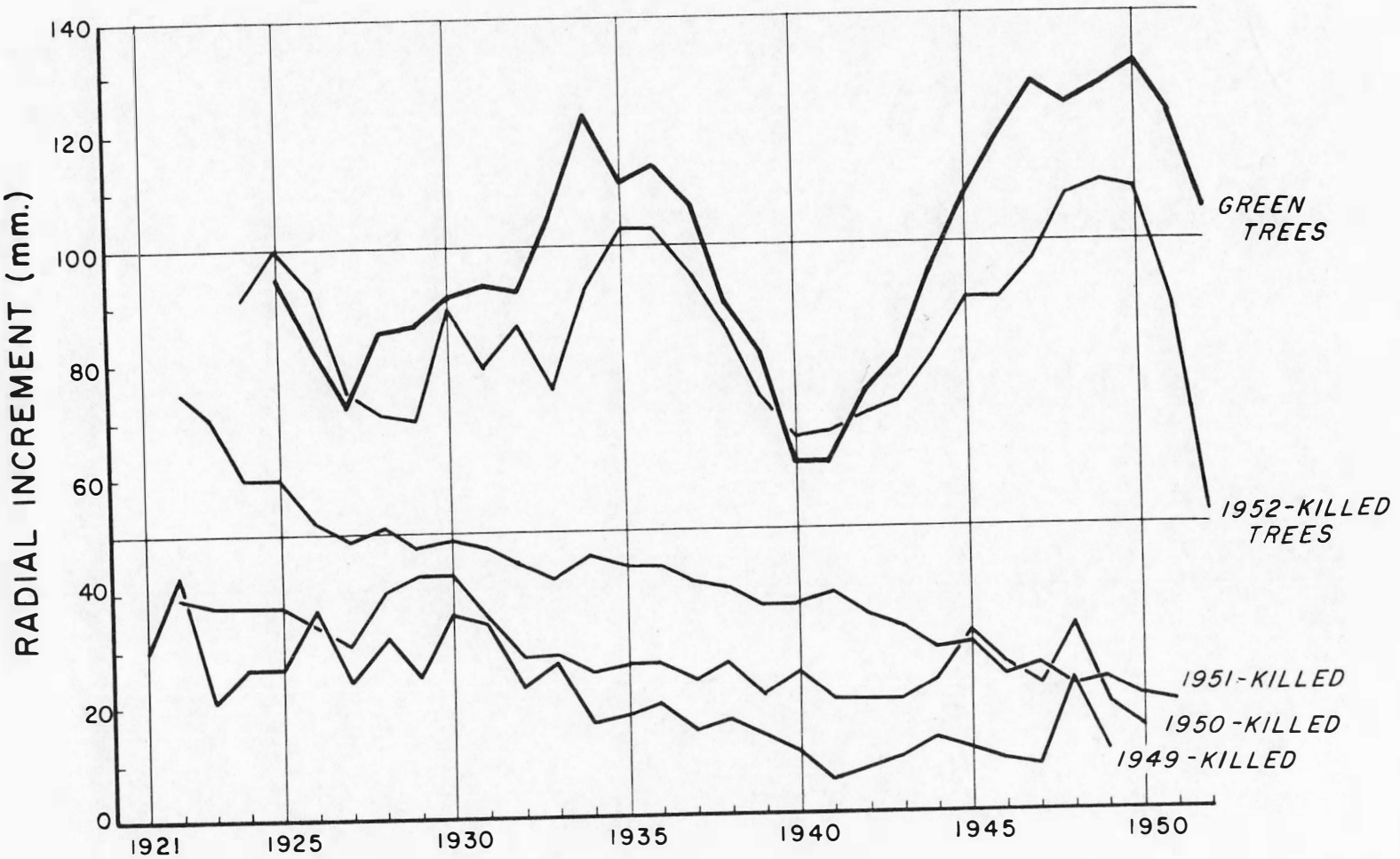

FIG. 3

RADIAL INCREMENT TREND